

# EXTREME WEATHER , SEA LEVEL RISE, AND TRANSPORTATION RESILIENCY IN THE TAMPA BAY AREA

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# Today

- FHWA funded study on transportation resiliency
- Relevance to regional cooperation on transportation investment
- Transportation resiliency take-aways

# FHWA 2018-2020 Pilot Program :

## Resilience & Durability to Extreme Weather

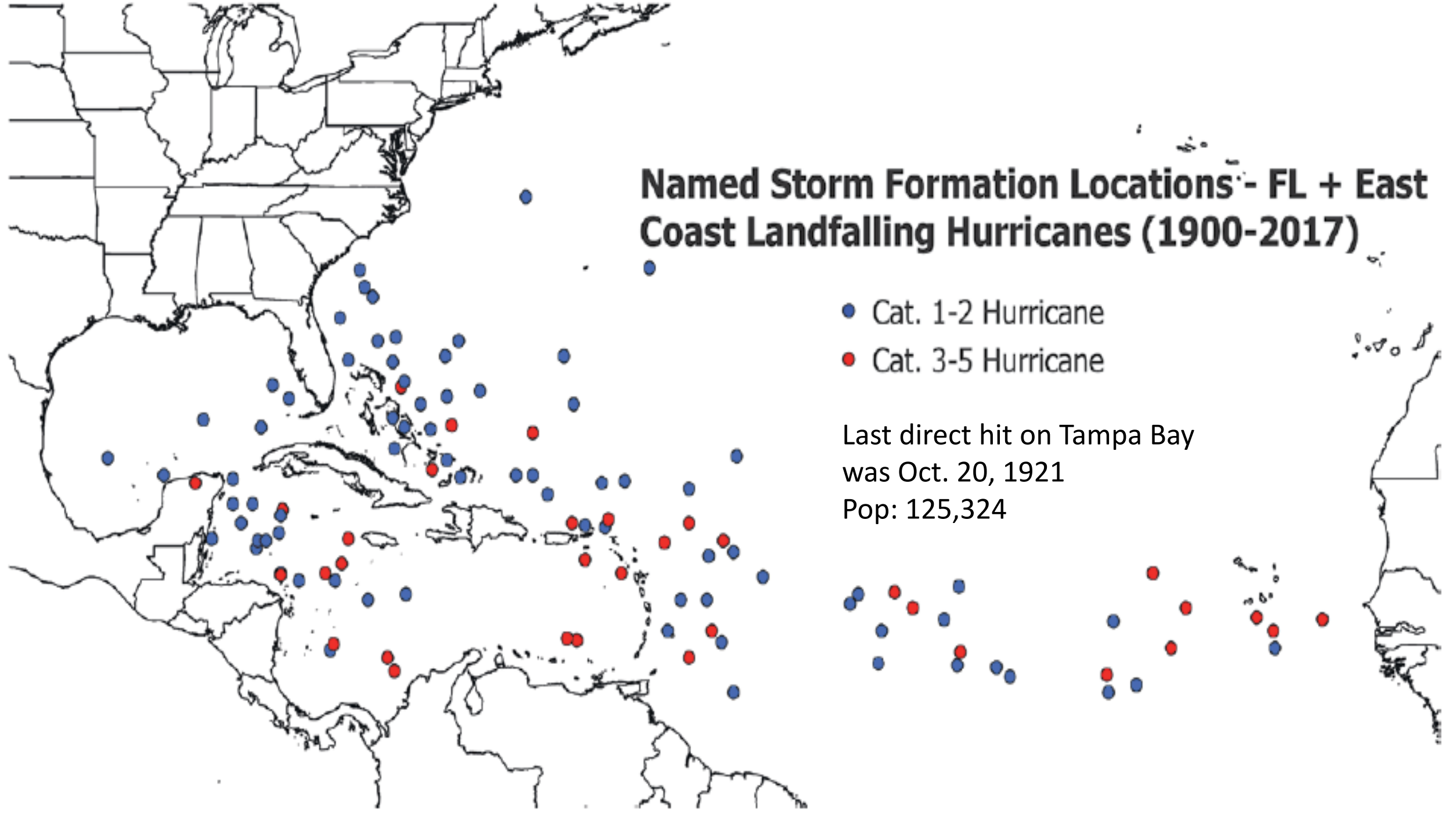
- 1 of 11 Pilot projects looking at integrating into agency practices, tools & resources , or deployment & monitoring.

- **Tampa Bay TMA**
- Caltrans
- MassDOT
- PennDOT
- Atlanta Regional Commission
- Corpus Christi MPO
- Mid-America Regional Council (Kansas City, MO & Johnson Co, KS)
- UDOT
- Quad Cities - Iowa/Illinois MPO
- Houston-Gaveston Area Council
- Naval Facilities Engineering Command (East and Gulf Coast)

# Overview

## Relationship to the Long Range Transportation Plan (LRTP)

- Regional vulnerability assessment of surface transportation assets focusing on **inland flooding**, **storm surge**, and **sea level rise**
- MPOs are required to adopt a new LRTP every 5 years (2045 planning horizon)
- Address **Fixing America's Surface Transportation (FAST) Act** requirements for MPO long range transportation planning:
  - Consider projects/strategies to improve the resilience and reliability of the transportation system; stormwater mitigation
  - Consultation with agencies and officials responsible for natural disaster risk reduction



## Named Storm Formation Locations - FL + East Coast Landfalling Hurricanes (1900-2017)

● Cat. 1-2 Hurricane

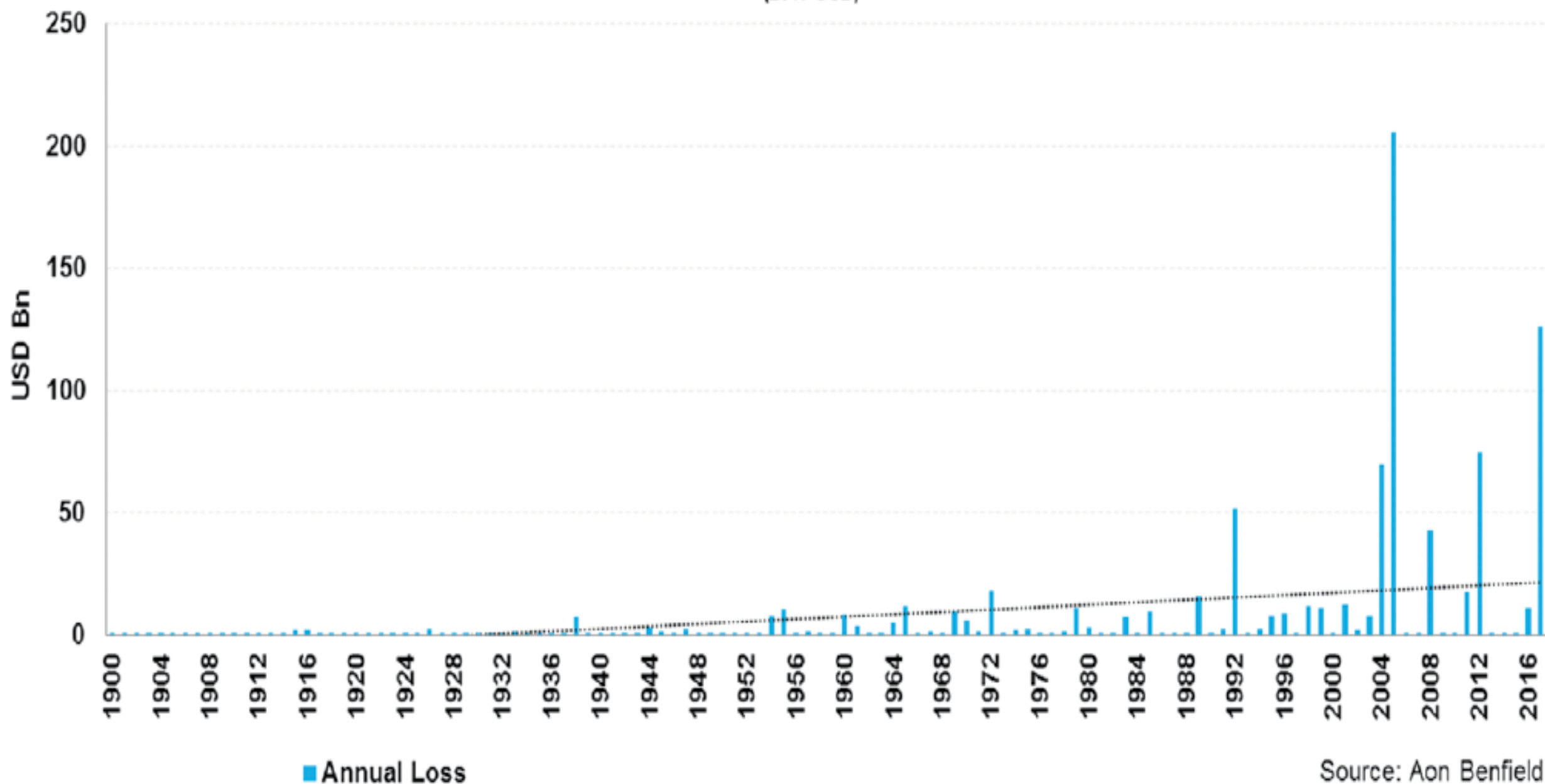
● Cat. 3-5 Hurricane

Last direct hit on Tampa Bay  
was Oct. 20, 1921

Pop: 125,324

# Continental US Economic Loss: Tropical Cyclone

(2017 USD)



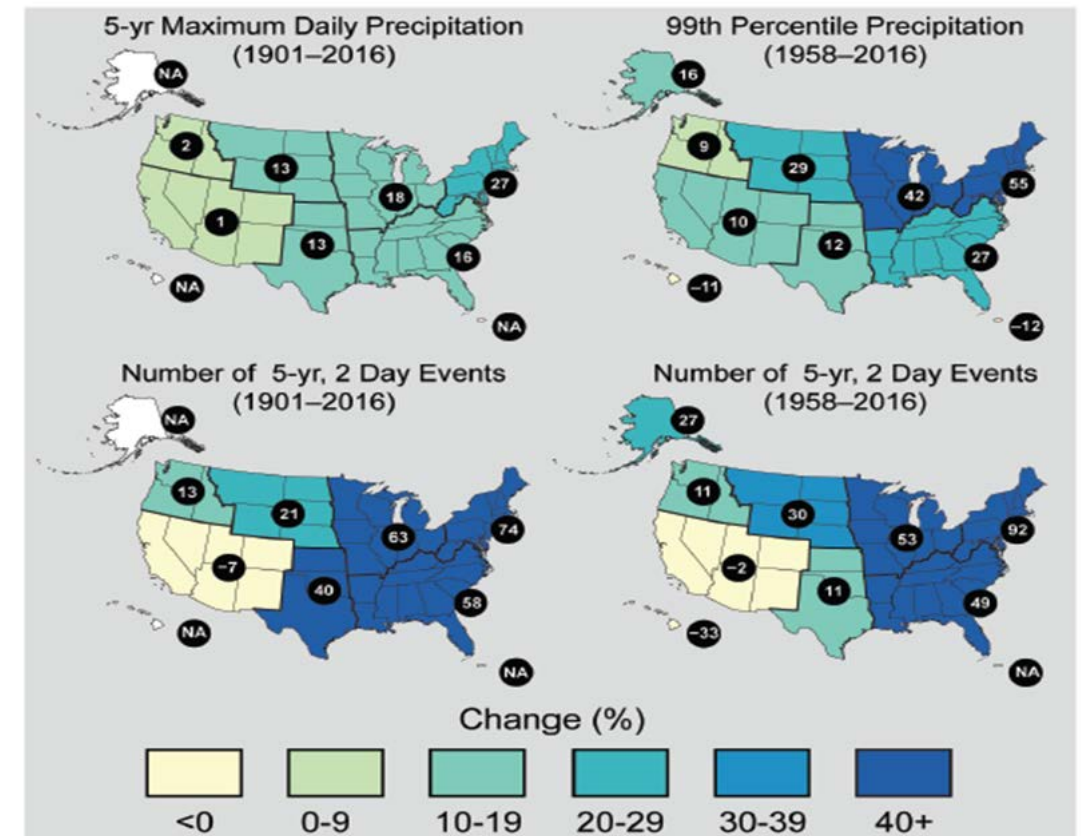
# Flooding Event Frequency in Tampa TMA

Hillsborough

Pasco

Pinellas

Extreme Precipitation Has Increased Across Much of the United States



Sources: [www.fema.gov/data-visualization-floods-data-visualization](http://www.fema.gov/data-visualization-floods-data-visualization);

Today's Tampa Bay population is 22 times larger than it was in 1921. 4 times larger than 1960.

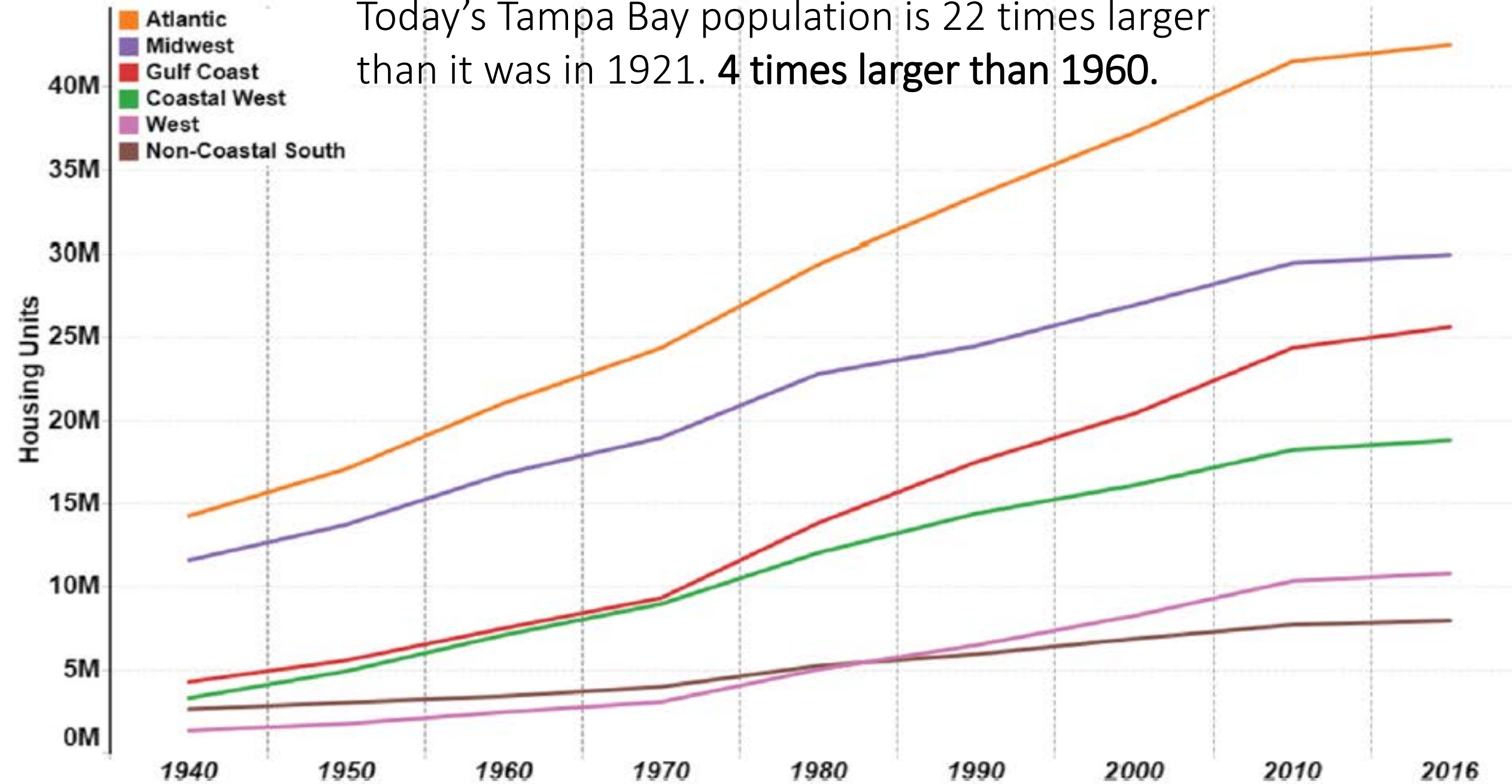
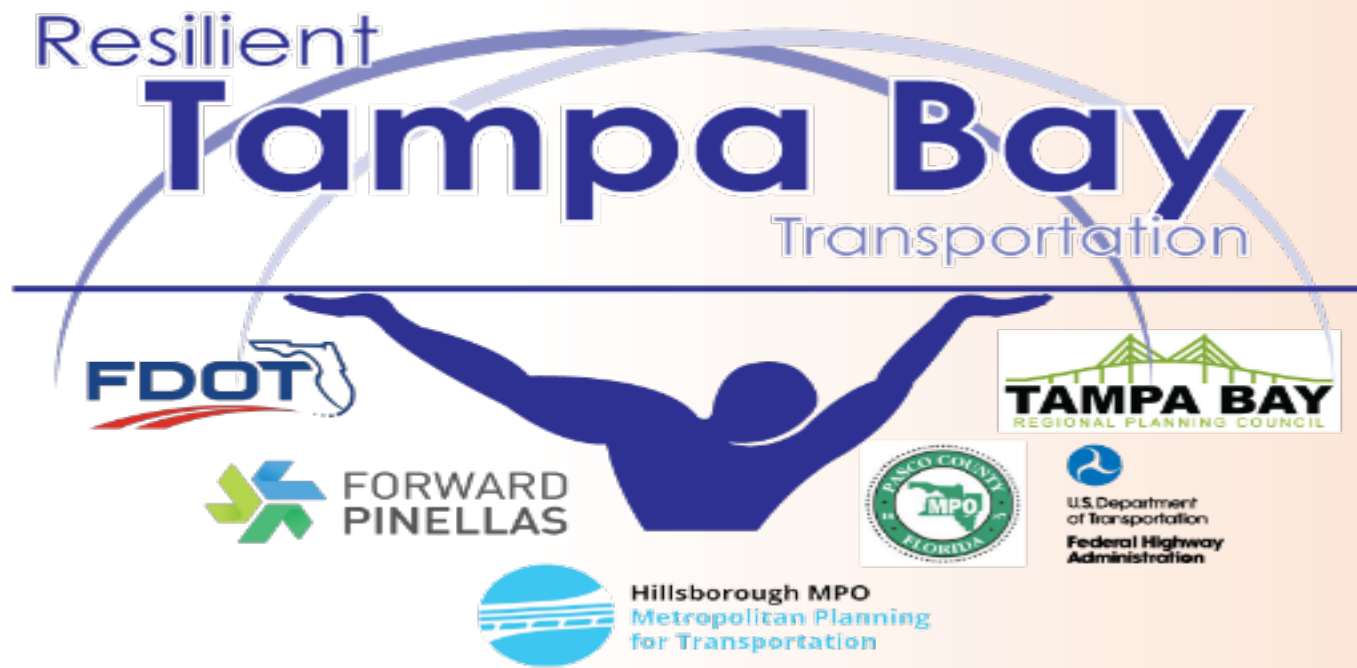


FIG. 10. CONUS decadal housing unit count (in millions) by region (1940–2016).



# FHWA Resilience & Durability to Extreme Weather Pilot Program

*presented to*

*Tampa Bay Transportation Area (TMA) Leadership  
Group*

*presented by*

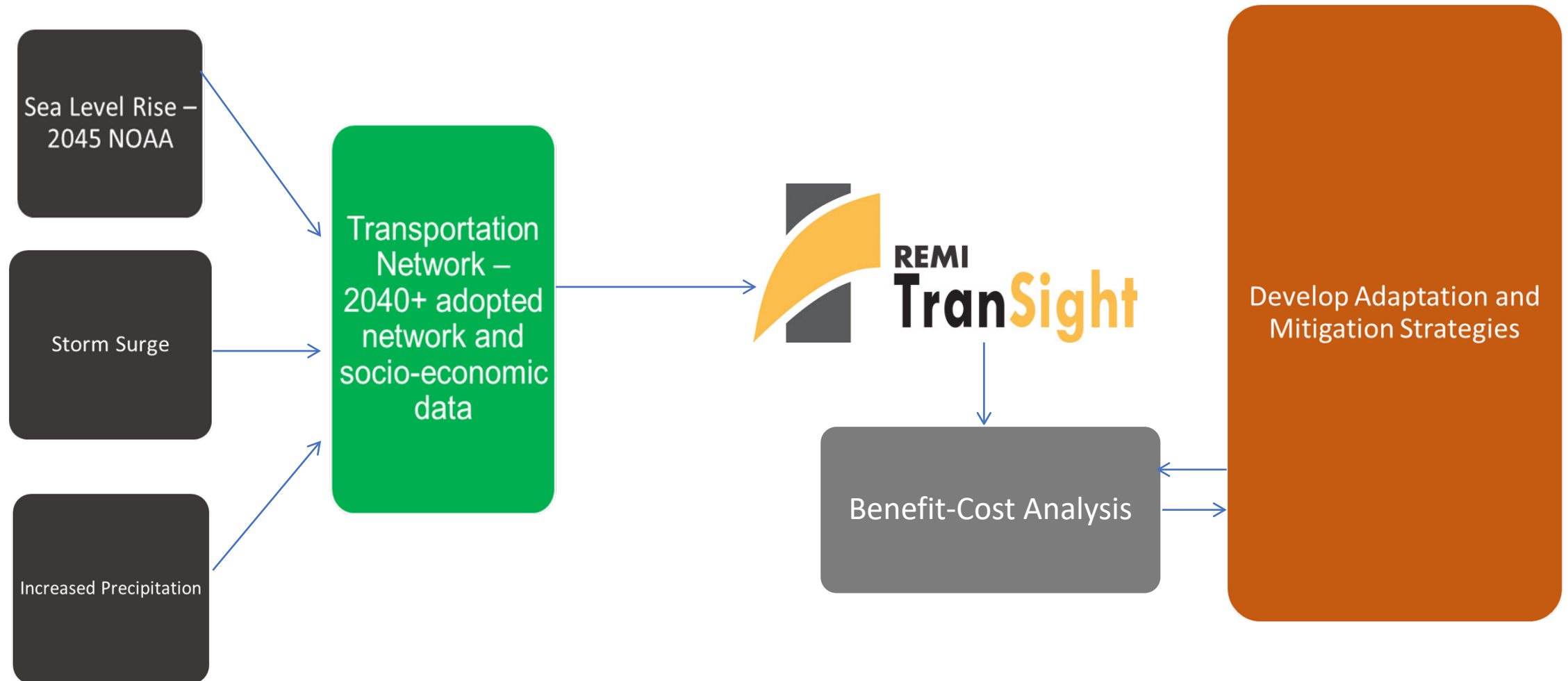
February 8, 2019

# Modeling Scenarios

- Sea Level Rise – 2045 NOAA
  - High and Intermediate-Low curves.
- Storm Surge - Current
  - Categories 1, 3, and 5
- Sea Level Rise plus Surge
  - Cat 1 High, Cat 1 Int-Low, **Cat 3 High**, Cat 3 Int-Low
- Precipitation
  - **9 inches rain in 1 day**; 33 inches rain in 3 days
- Transportation – 2040
  - Adopted network and socio-economic data
- Economic Analysis – 2045

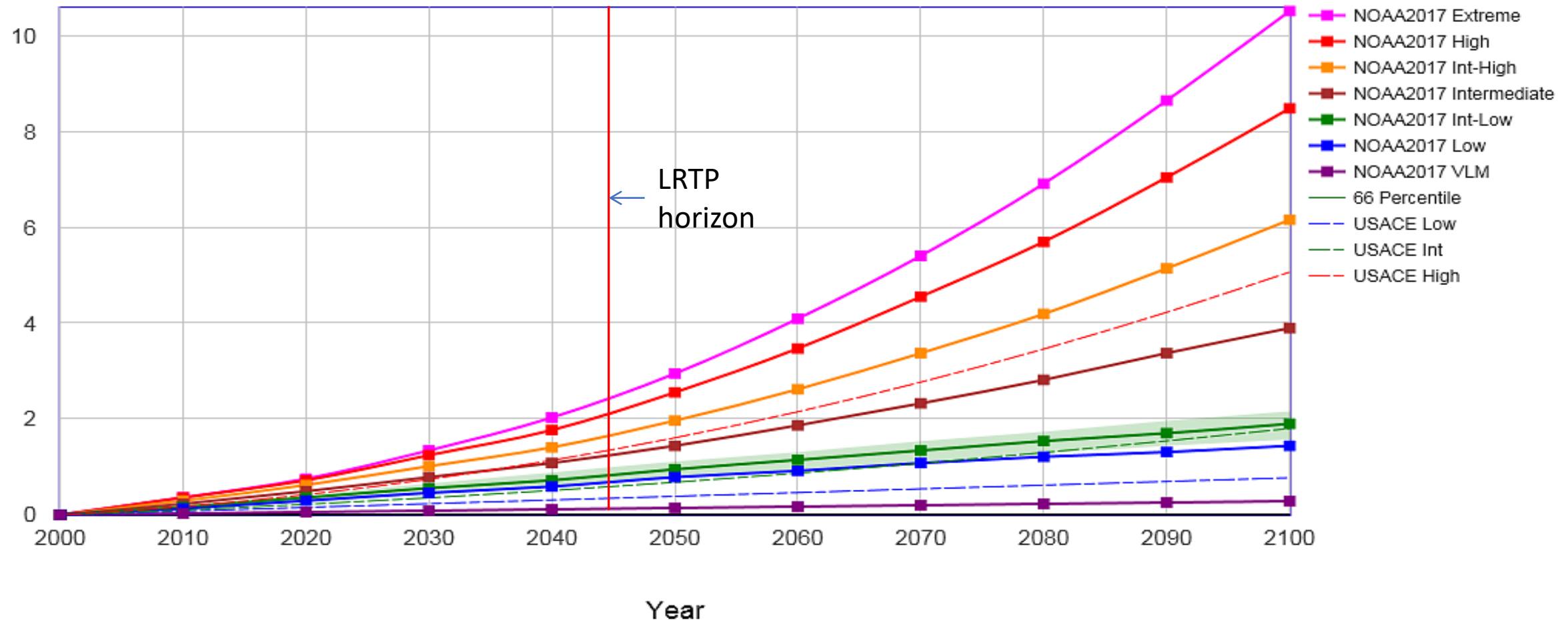
| Population In | TMA         |
|---------------|-------------|
| 2019          | 2.8 Million |
| 2045          | 3.8 Million |

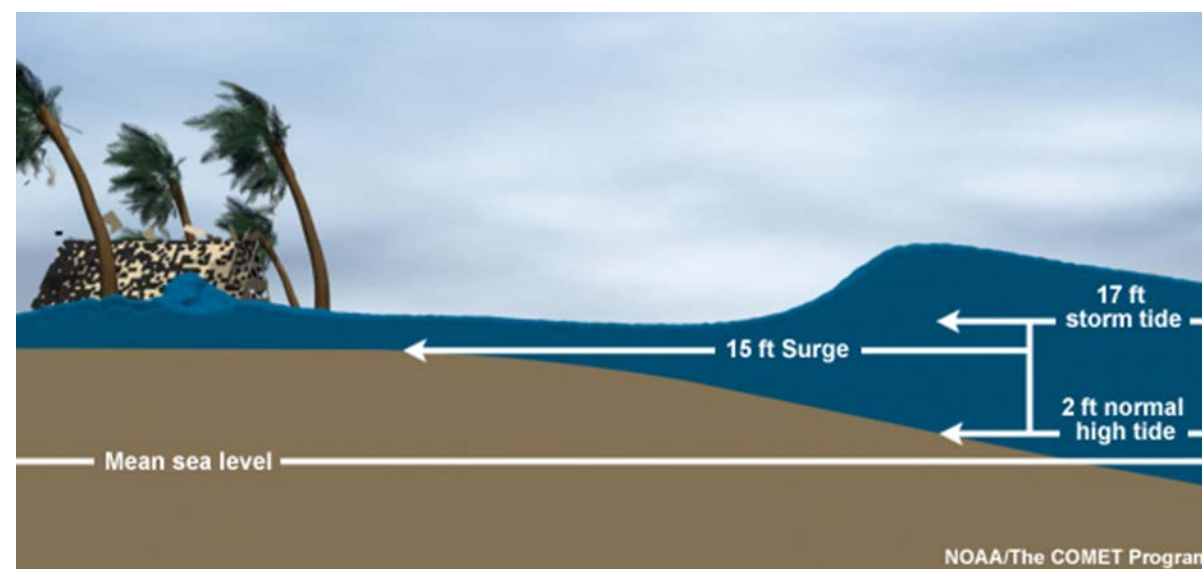
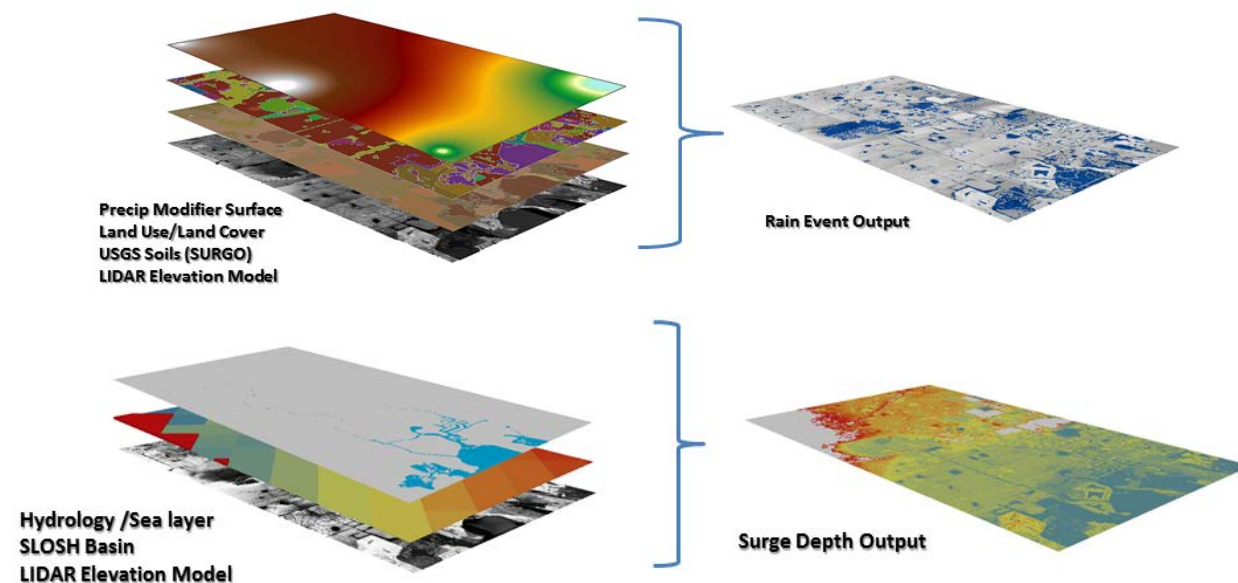
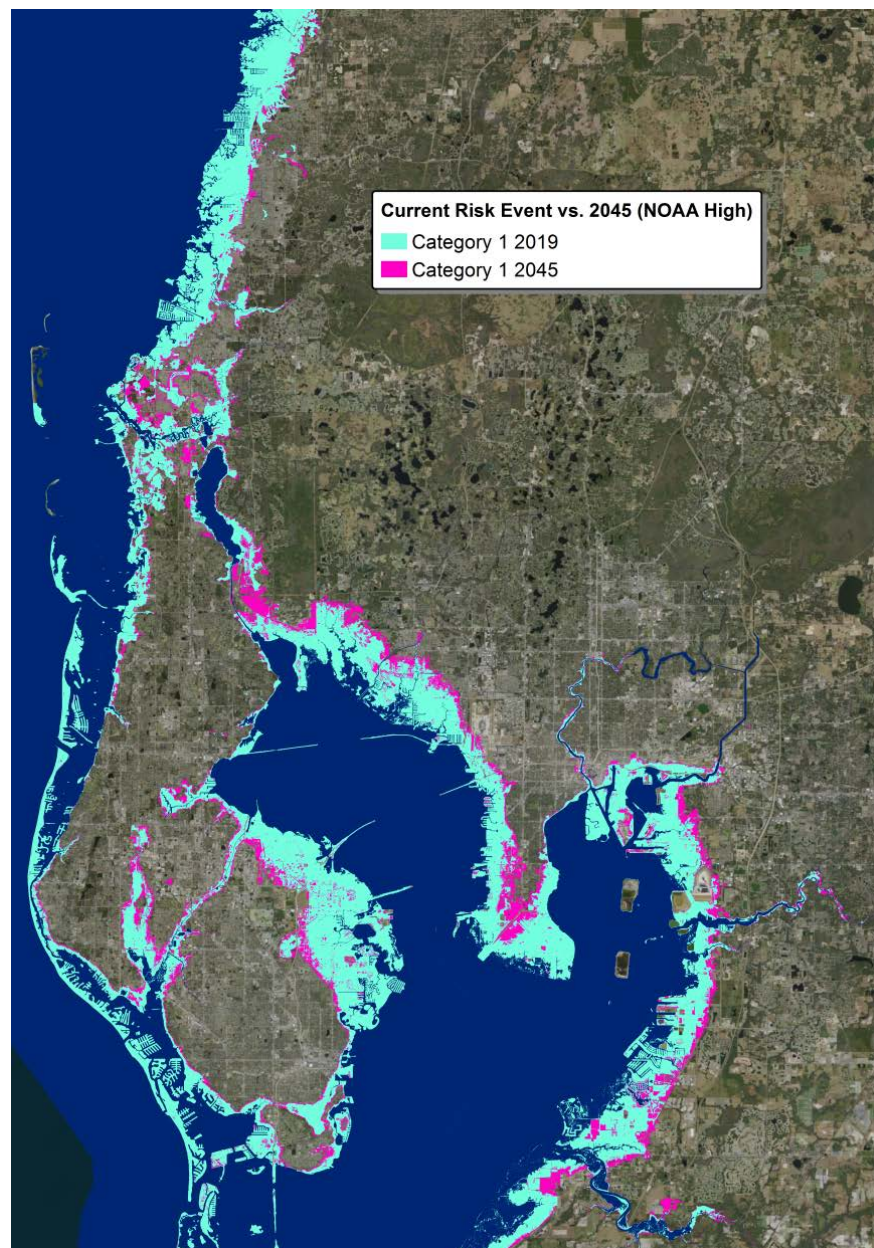
# Pilot Study Technical Process



# Sea Level Change Scenarios

NOAA et al. 2017 Relative Sea Level Change Scenarios for : ST. PETERSBURG





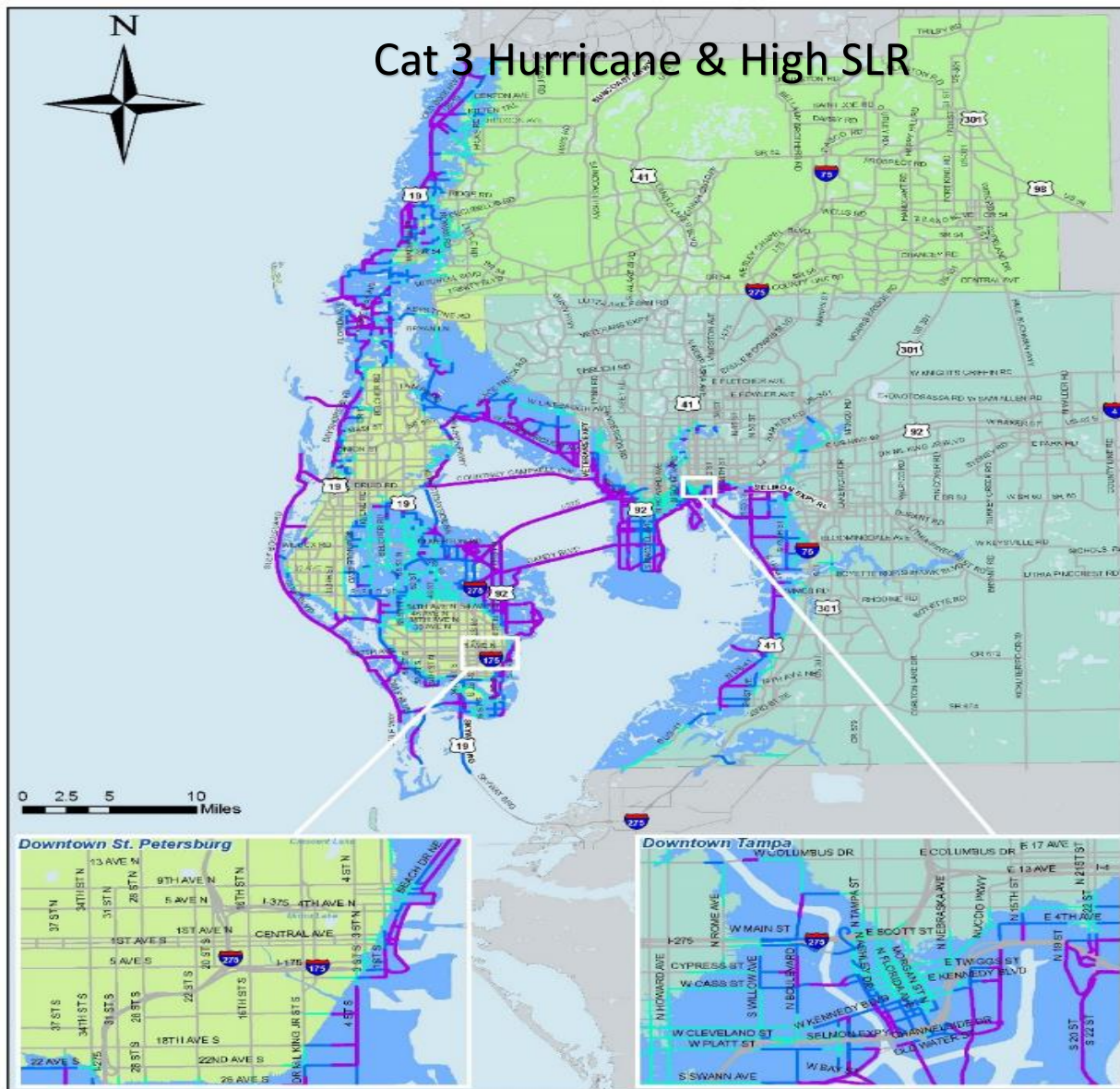




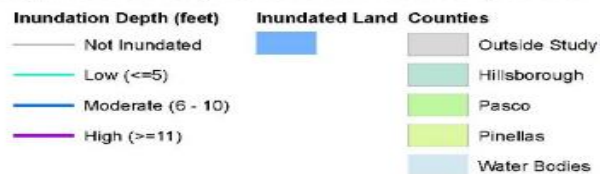




# Cat 3 Hurricane & High SLR

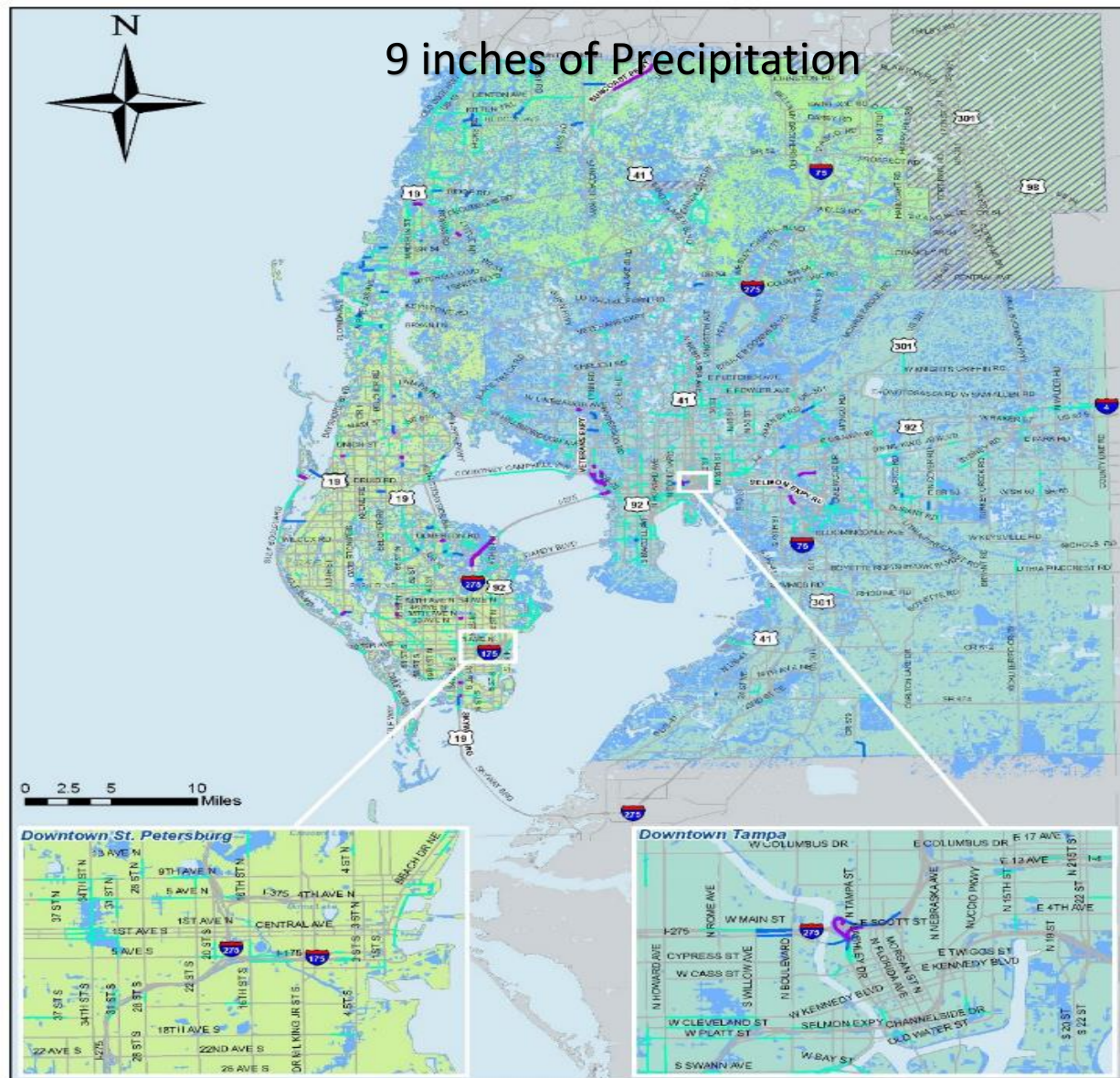


## Transportation Facilities Vulnerability Category 3 Storm plus 2045 High Sea Level Rise Projection



Date: 4/1/2019

# 9 inches of Precipitation



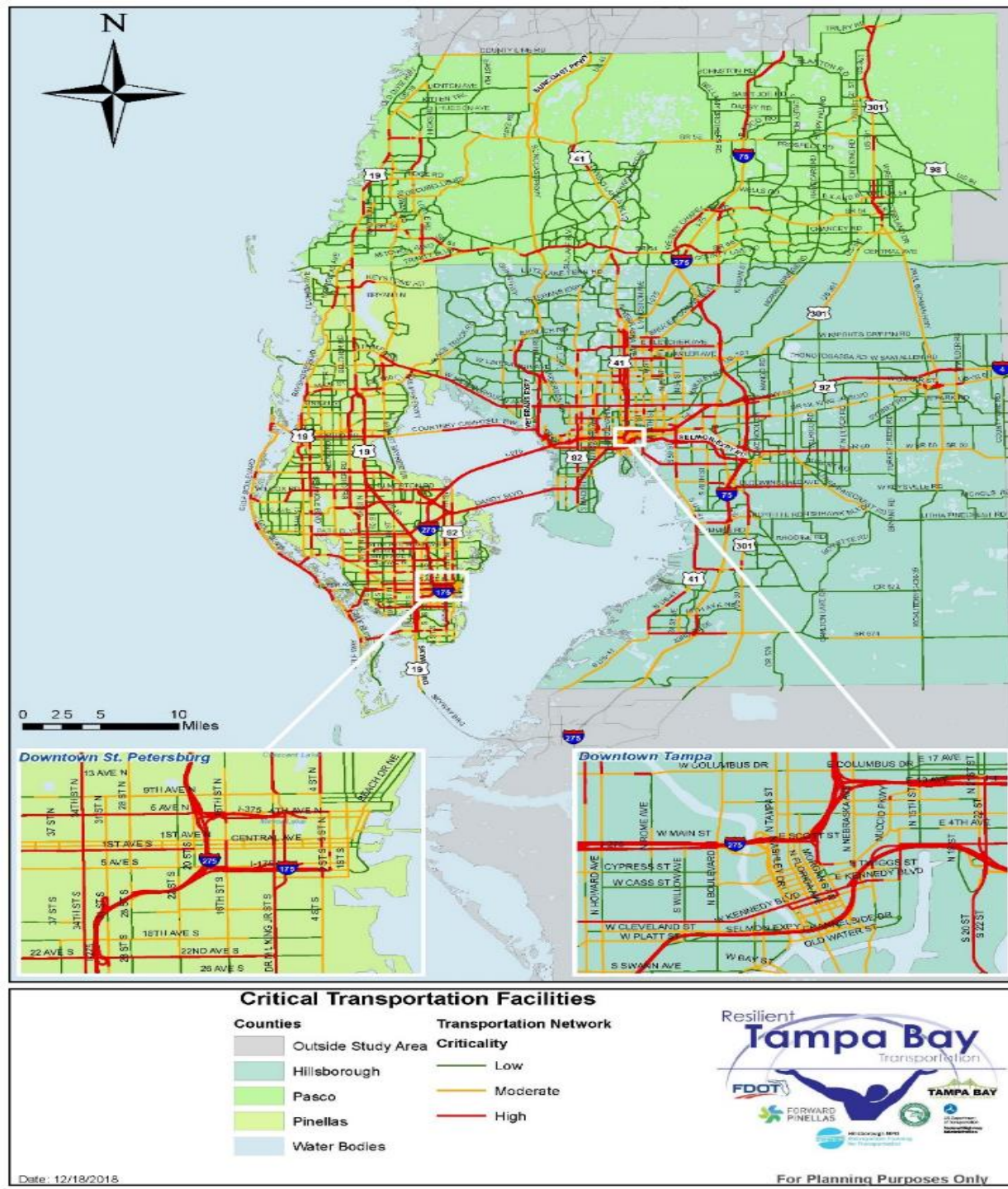
## Transportation Facilities Vulnerability - 9 Inches Precipitation



Notes: Due to the lack of unified DEM source, the hydrology model is not able to produce meaningful results for the eastern part of Pasco County.

Date: 4/2/2019

# Criticality Factors



| Factor                                                                                                                   | Max |
|--------------------------------------------------------------------------------------------------------------------------|-----|
| Evacuation Route                                                                                                         | 3   |
| Projected 2040 Traffic volume                                                                                            | 3   |
| Proximity or primary route to major economic and social activity centers                                                 | 3   |
| Projected Population density                                                                                             | 3   |
| Transit Corridor                                                                                                         | 2   |
| Part of adopted land use and/or transportation plans (ex. LRTP, TIP, SIS, National Highway Freight Network)              | 2   |
| Projected Employment density                                                                                             | 2   |
| Percentage of Zero-Car Households                                                                                        | 2   |
| Intermodal Connectivity (Port/Rail connectors)                                                                           | 1   |
| Projected Truck Traffic or Freight Corridor                                                                              | 1   |
| Equity areas (Environmental Justice/Disadvantaged Populations, as identified by the metropolitan planning organizations) | 1   |

# 6 Representative Projects

## » Hillsborough

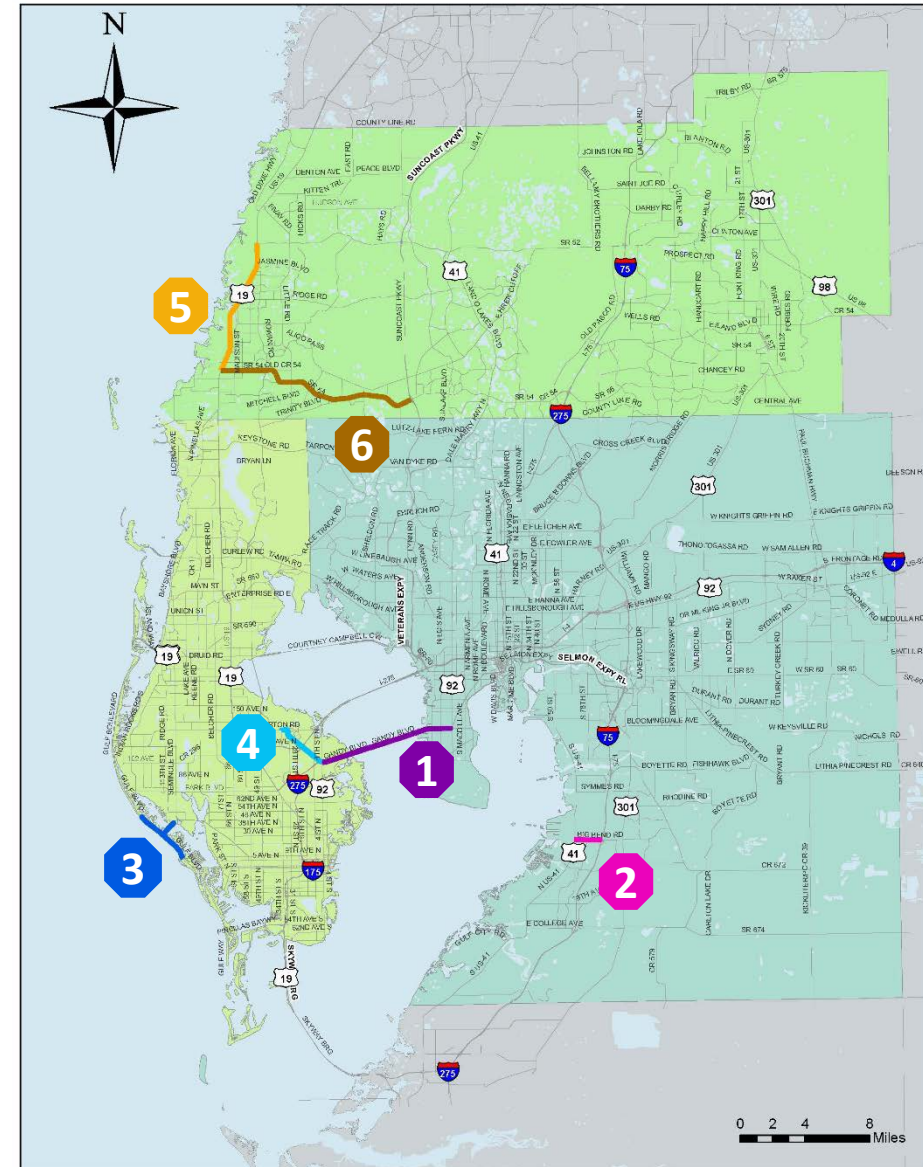
1. Gandy Blvd from 4th St to S Dale Mabry Hwy
2. Big Bend Rd from US-41 to I-75

## » Pinellas

3. Gulf Boulevard from Bath Club Circle to 125th Ave & Tom Stuart Cswy Bridge
4. Roosevelt Boulevard from Ulmerton Road to Gandy Blvd

## » Pasco

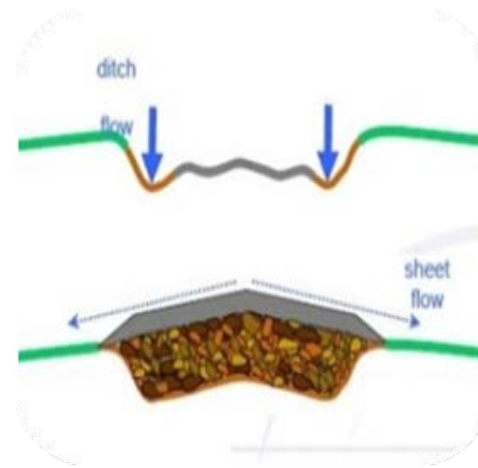
5. US 19 from S.R.54 to S.R.52
6. S.R.54 from US 19 to Suncoast Pkwy



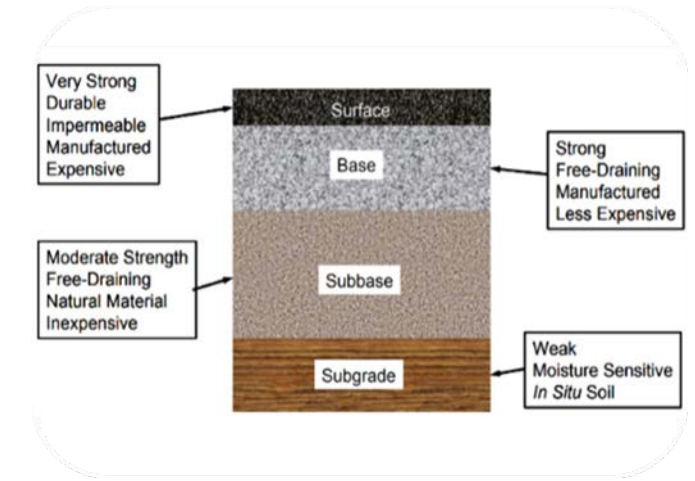
# Adaptation Strategies

- Physical asset adaptations
  - Design changes
- Natural landscapes
  - Topographical changes
  - Vegetation
  - Wave mitigation
- Water management
  - Drainage and flood control

Raise Road Profile



Enhance road surface/subbase



Soil mats



Biofiltration swales



Seawalls



Wave attenuation



# Extreme weather impacts on commuters and goods movement



## **Travelers Pay More**

Results in loss of time at work and with family due to re-routing or inaccessibility



## **Labor force impacts**

Firms lose \$ due to lost productivity labor may not be available due to evacuations.



## **Increased Travel Time**

Longer travel time for transit riders (or no trips at all).



## **Increased Inventory Costs**

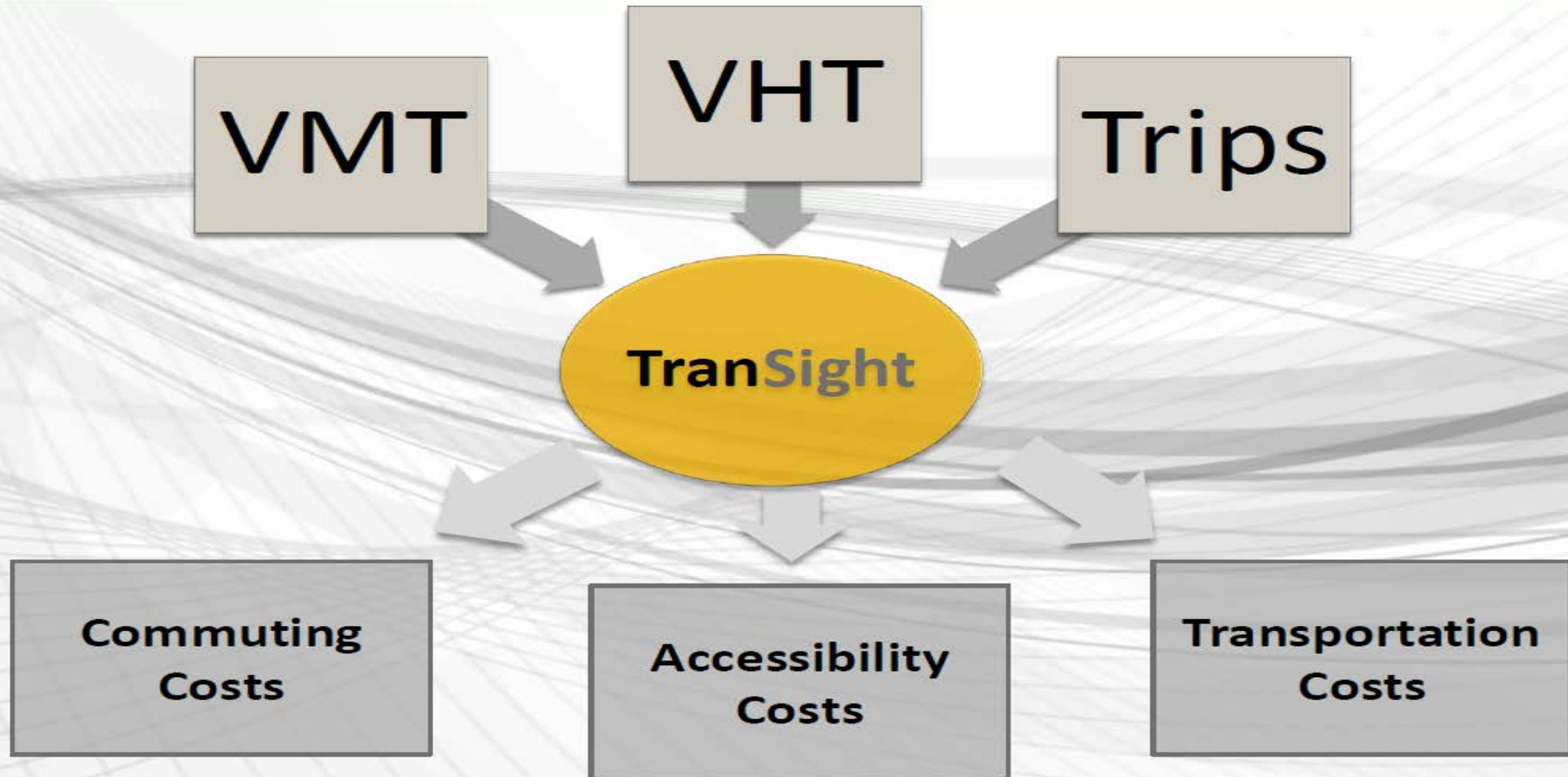
Increases in inventory safety stocks to offset storm purchases. Supplies may be disrupted.



## **Delivery Costs**

Increase in delivery costs, potential loss of perishables, breakdown in the cold-chain. Chain effects as suppliers fail, disrupting otherwise prepared businesses

# Integration with TranSight



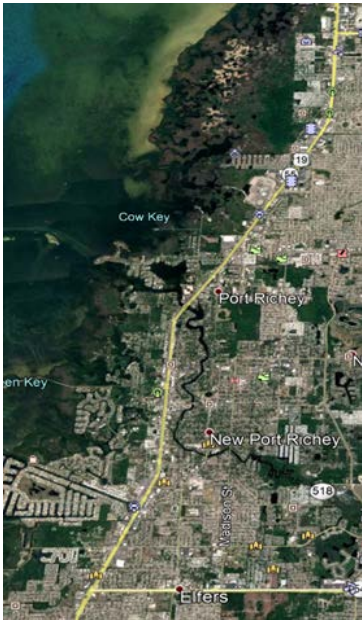
# TranSight Advantages

- Converts travel model outputs into a more policy-framing friendly framework
  - Changes in county-to-county flows and RTDM outputs and maps changes in Gross Regional Product, personal income, population, labor force, residence-adjusted employment, relative change in prices between counties
  - RTDM outputs and TranSight outputs can be used to tell important policy 'stories'
- Results may appear to be anomalous
  - A facility failing in Bedroom County will induce greater GRP losses in Grande Jobs County and Tall Jobs County than in Bedroom County because commuter cost increases are borne by firms
  - Over long-run time frames, lower transportation costs may convey comparative advantages to other counties

# Scenarios

- Two days: Extensive flooding
- 1 Week: Some areas may still experience spot flooding, debris and downed power lines and traffic lights
- 2 Weeks to 1 Month: structural damage to the road

# US 19 from S.R.54 to S.R.52 (Pasco County)



| Economic Impact                                              | 1 Week 2045 | Adaptation              |
|--------------------------------------------------------------|-------------|-------------------------|
| Gross Regional Product<br>(Millions of Fixed (2018) Dollars) |             | Costs*<br>(\$ Millions) |
| Hillsborough                                                 | -\$14.6     |                         |
| Pasco                                                        | -\$30.2     |                         |
| Pinellas                                                     | -\$44.3     |                         |
| Tri-County Total                                             | -\$89.1     | \$136.3                 |

## Adaptation Options:

### Preferred Option:

Raise roadway profile and add soil mat on both sides, 25-foot width. A complementary action would be to enhance the natural shoreline.

Cost: \$136,273,000

### Better:

Raise profile 4 feet at major intersections for 500 feet in all directions, assume one per mile, and assume reconstructing two major box culverts or minor bridges per mile.

Cost: \$49,582,000

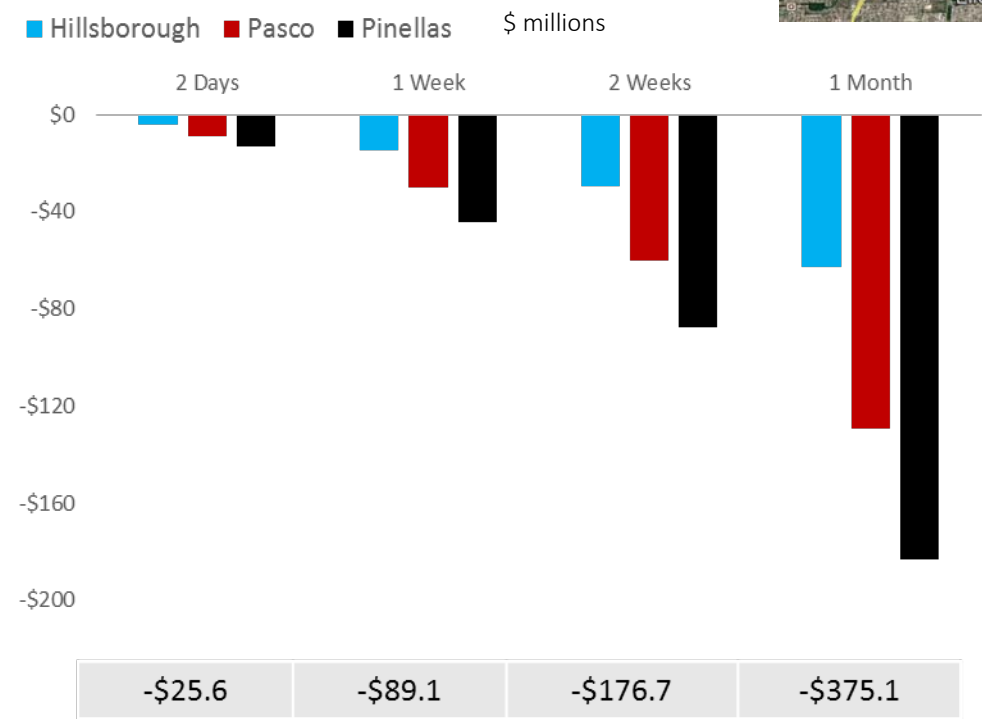
### Good:

Harden road on sides (add soil mat both sides, 25’ width) to increase protection from flow

Cost: \$4,563,000

\* All 3 options combined

## U.S. 19

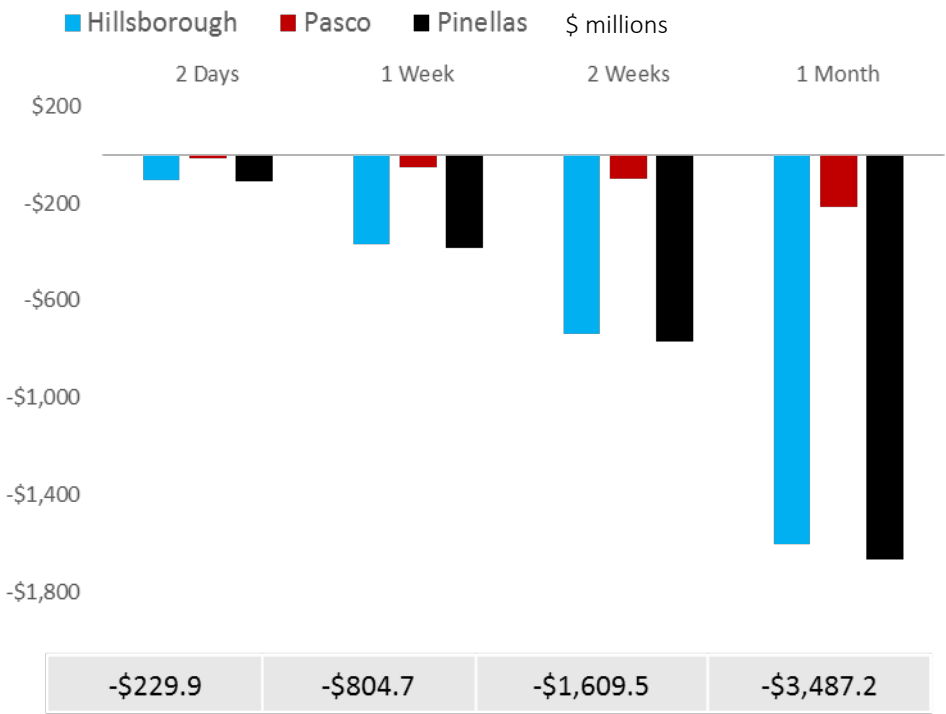


# Gandy Blvd from 4th St to S Dale Mabry Hwy (Hillsborough-Pinellas)



| Economic Impact                                              | 1 Week 2045 | Adaptation              |
|--------------------------------------------------------------|-------------|-------------------------|
| Gross Regional Product<br>(Millions of Fixed (2018) Dollars) |             | Costs*<br>(\$ Millions) |
| Hillsborough                                                 | -\$370.4    |                         |
| Pasco                                                        | -\$49.2     |                         |
| Pinellas                                                     | -\$385.1    |                         |
| Tri-County Total                                             | -\$804.7    | \$74                    |

## Gandy



## Adaptation Options:

### Preferred Option:

Raise roadway profile 4 feet near bridge entrances

Cost: \$46,751,000

If the bridges are reconstructed as two separate projects, assume each project will cost 70% of the total, or \$32,726,000

### Better:

Widen existing ditch on one side to 10 foot flat bottom with 4:1 side slopes, 6 foot depth

Cost: \$6,822,000

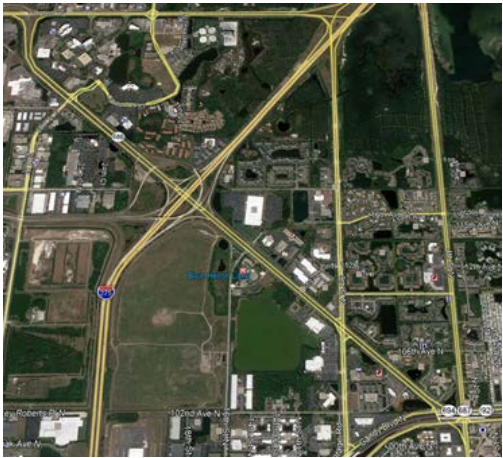
### Good:

Add soil mat on both sides, 25-foot width, and consider wave attenuation devices

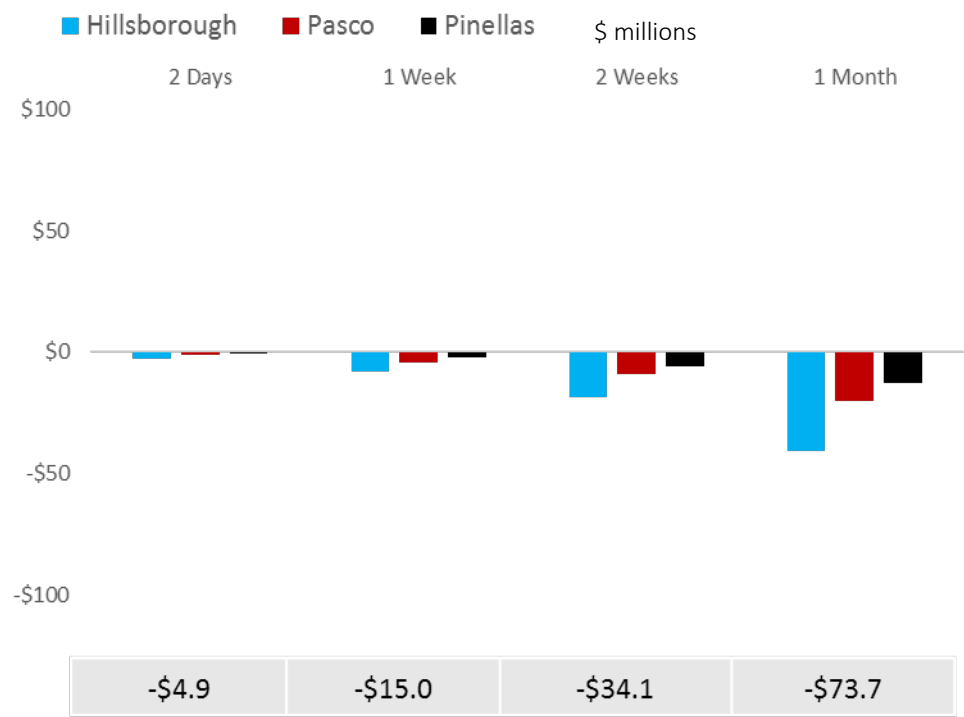
Cost: \$1,755,000

\* All 3 options combined

# Roosevelt Boulevard from Ulmerton Road to Gandy Blvd (Pinellas)



## Roosevelt



| Economic Impact                                              | 1 Week 2045 | Adaptation              |
|--------------------------------------------------------------|-------------|-------------------------|
| Gross Regional Product<br>(Millions of Fixed (2018) Dollars) |             | Costs*<br>(\$ Millions) |
| Hillsborough                                                 | -\$8.3      |                         |
| Pasco                                                        | -\$4.6      |                         |
| Pinellas                                                     | -\$2.1      |                         |
| Tri-County Total                                             | -\$15.0     | \$16.4                  |

## Adaptation Options:

### Preferred Option:

Mill 1", resurface with 3 inches new asphalt, resulting in 2 inches additional pavement

Cost: \$6,486,000

### Better:

Widen existing ditch on one side to 10 foot flat bottom with 4:1 side slopes, 6 foot depth

Cost: \$6,003,000

### Good:

Raise median and add soil mat to protect from erosion

Cost: \$3,938,000

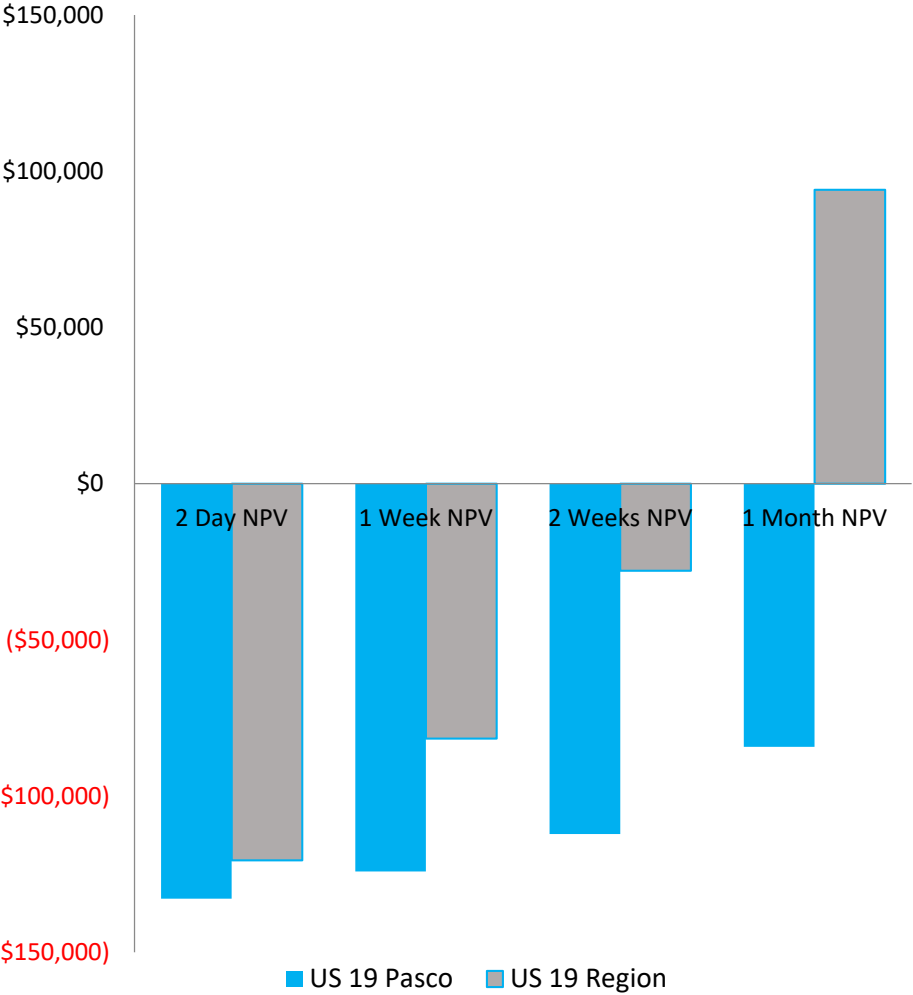
\* All 3 options combined

# Benefit-Cost Analysis

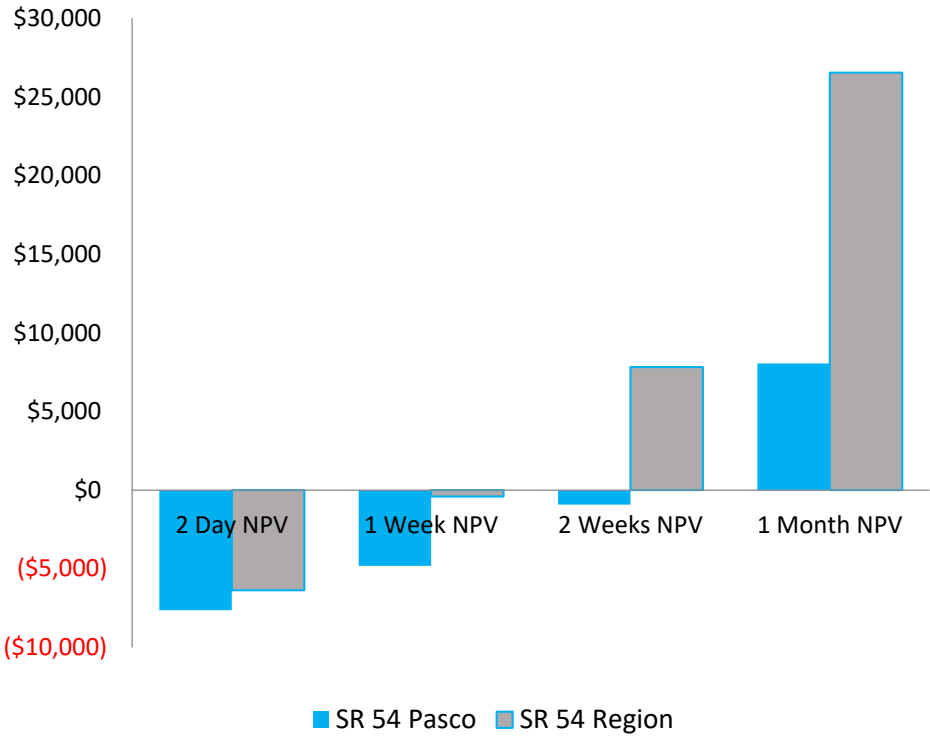
- Benefits are **only** avoided transportation costs, not avoided property costs or other. Costs are **only** investment in adaptation costs.
- Analysis for Year 2045 and Years 2045-50
- 4% discount rate, per [FDOT Guidance](#)
- Assumes very near term adaptation capital investment

Pasco County Representative Projects NPV (2018 \$1,000s)

US 19

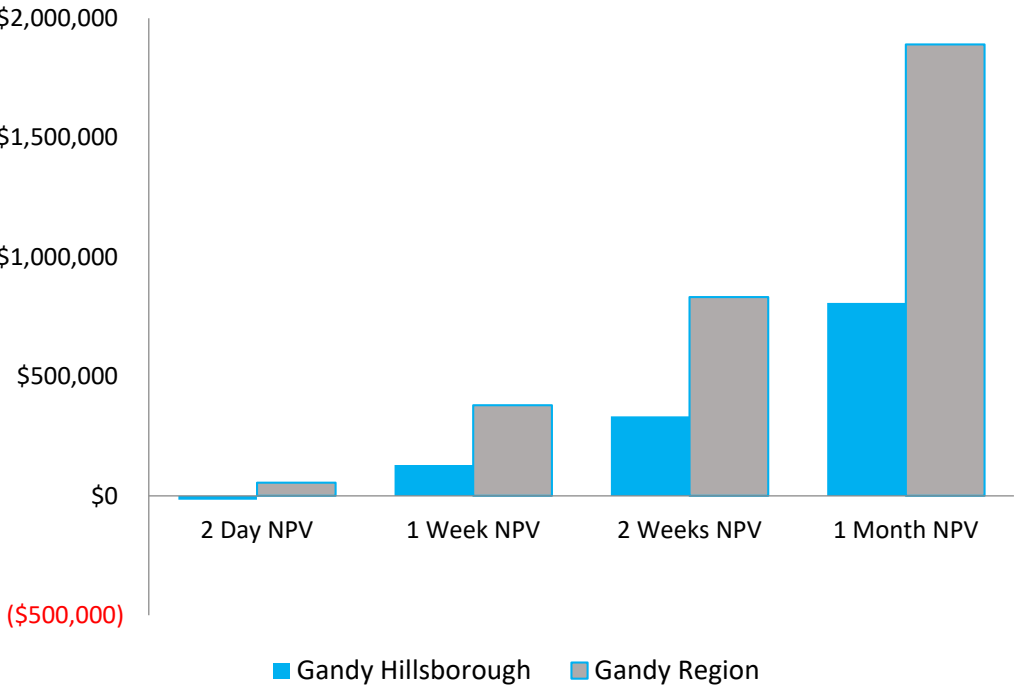


SR 54

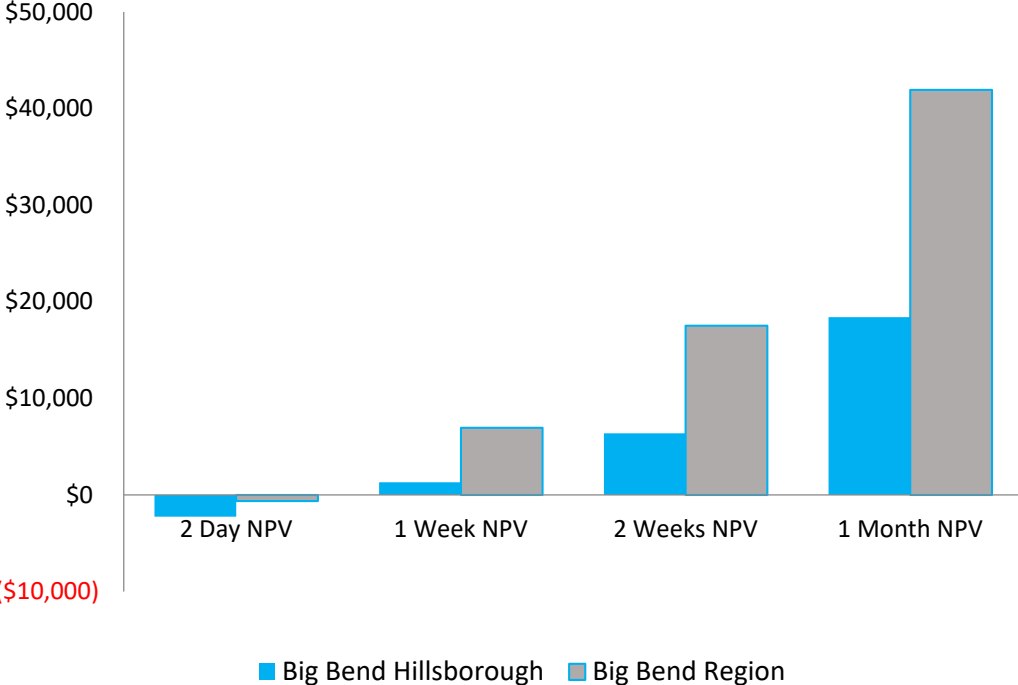


Hillsborough County Representative Projects, NPV (2018 \$1,000s)

Gandy Blvd

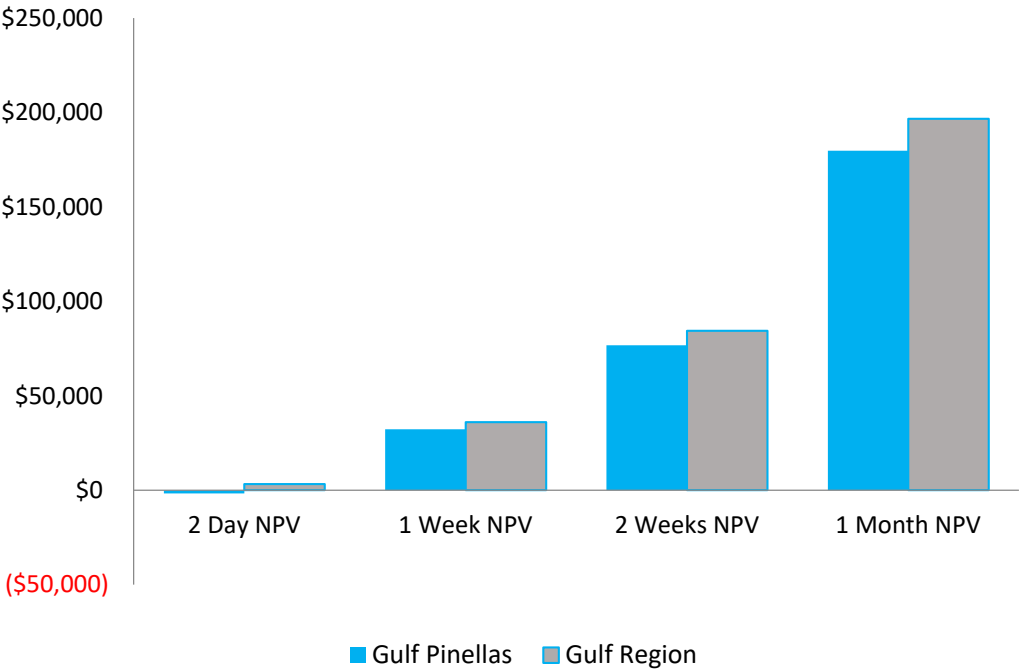


Big Bend

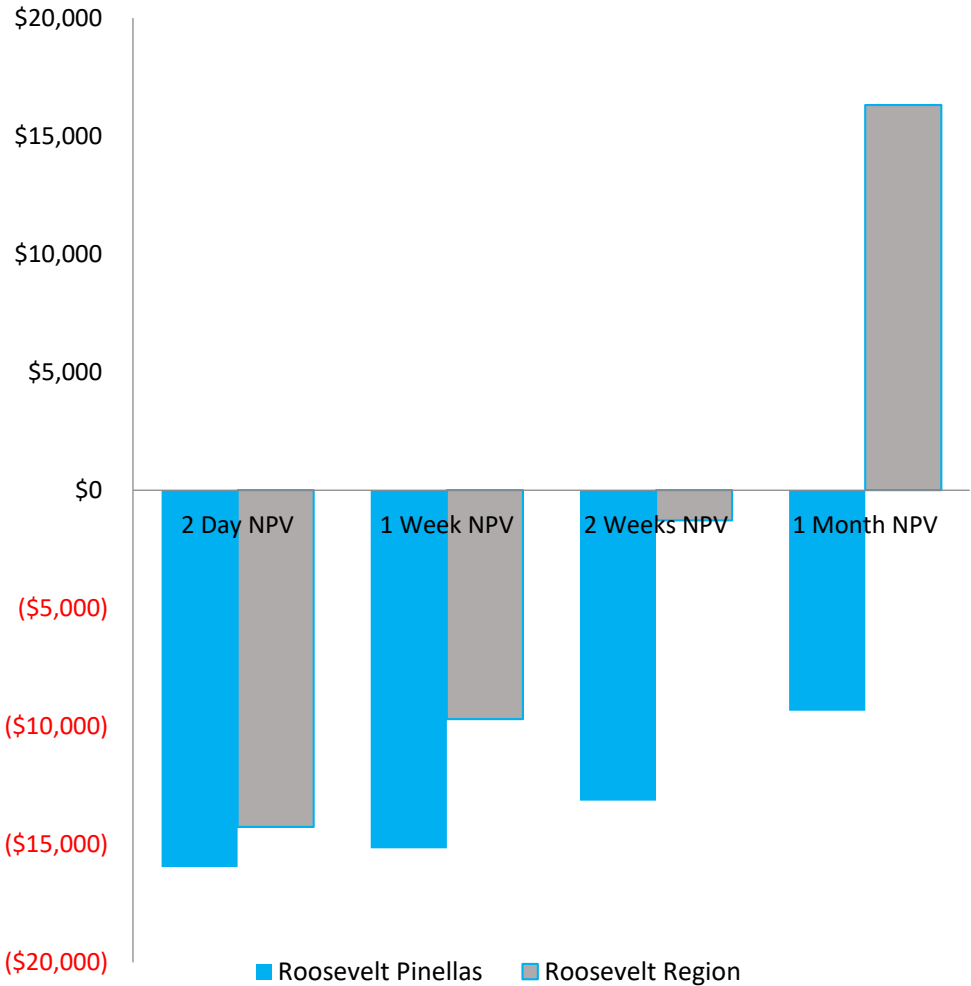


Pinellas County Representative Projects, NPV (2018 \$1,000s)

Gulf Blvd

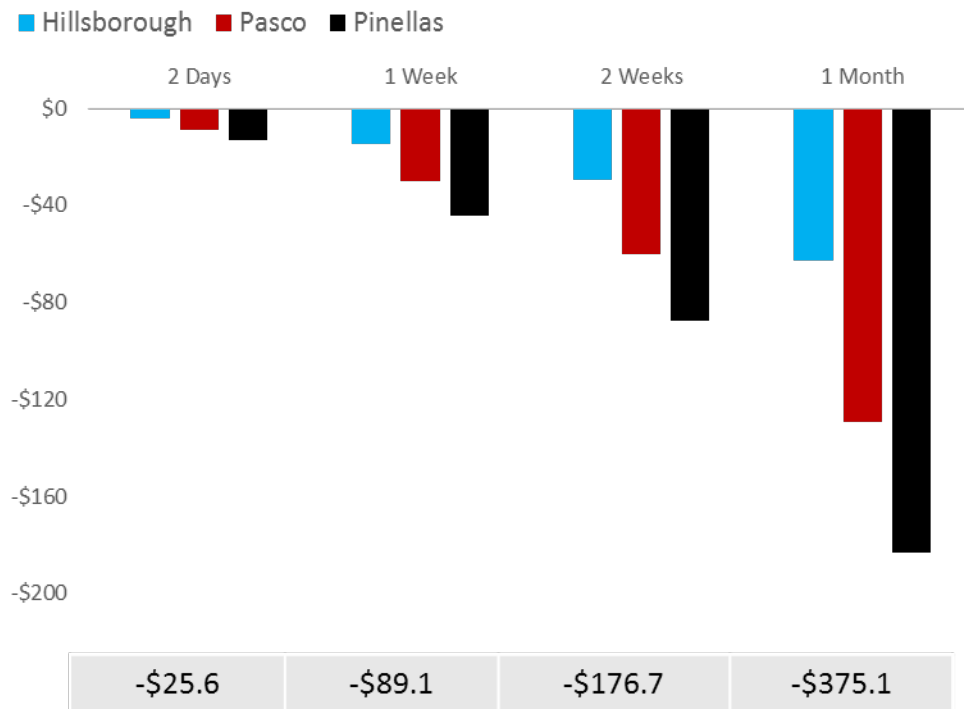


Roosevelt Blvd



# TranSight and Regional Investment

U.S. 19



- 2019: Study of merging MPOs
- Adjacent counties benefit/lose more than counties with the affected facility
- All impacted counties have a stake in each other's major facilities
- Case for regional prioritization in critical facilities or prioritization of major regional projects

# Transportation Resiliency Take-Aways

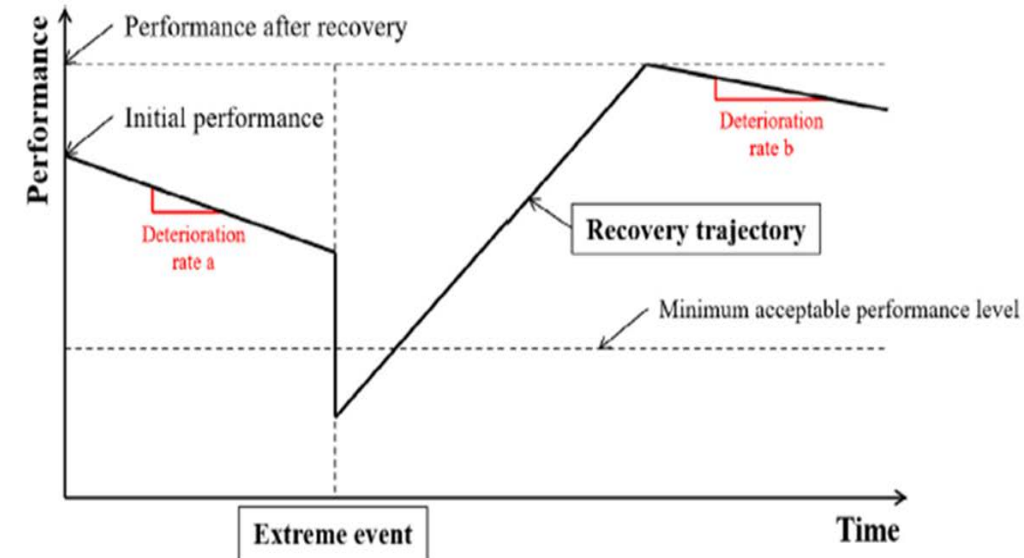


Fig. 1. Life-cycle performance of an infrastructure system exposed to evolving conditions.

- Facility robustness
- System reliability (minimizing travel time volatility across events)
  - Return to status quo ante timeframe
  - Interconnectivity and network redundancy
- Long-term maintenance costs versus risks
- Adaptation should be consistent with climate mitigation through multimodality

# Some Caveats

- Short-lived network disruptions may have more limited long-run/magnitude impacts than results indicate
- One time extreme event versus many events
- Benefits from adaptation are assumed to be 100% avoided costs
- Travel Model results reflect system wide network impacts of individual project failures, not impacts on adjacent land uses
- There is considerable variation in sea level rise impact estimates
- Travel demand impacts are estimated for 2045, when sea level rise impacts are relatively low compared to the long run





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# Fat-Tailed Risk and Extreme Weather

- Low probability high impact events
- Fat tail PDF of damage function assigns much higher probability to extreme events than a normal distribution
- Weizman— PDF tails fattened by structural uncertainty can have a big effect on CBA (2009)
- Conventional CBA imposes arbitrary cut-offs for low probability events, but climate risks are fatty tailed and the costs of low probability events are much higher than in conventional CBA

# US 19 Impacts

- Even though there is a loss of GRP in Hillsborough County as the result of this disruption, Hillsborough sees a small gain in personal income. Hillsborough would become a relatively more attractive place to live because the transportation, accessibility, and commuting cost increases are not as high as in other counties
- Hillsborough residence adjusted employment has increased, meaning that there is an increase in people living within Hillsborough and working outside the county. Because they are living in Hillsborough, personal income increases within the county. Even though there is a net decrease in population and labor force, there is still a net increase in residence adjusted employment (for example, if ten people move out of a region and 5 people move into the region and work in a different region, there is still a net decrease of five people but there would be a residence adjusted increase of five people).